SYDNEY BOYS HIGH SCHOOL

Trial Physics Examination

2011

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board- approved calculators may be used
- A data sheet, and formulae sheets Periodic Table are provided at the back of this paper

Total marks - 100

Section 1

75 marks
This section has two parts, Part A and Part B

Part A – 20 marks
- Attempt questions 1 – 20
- Allow about 35 minutes for this part

Part B - 55 marks
- Attempt Questions 21-32
- Allow about 1 hour and 40 minutes for this part

Section II
25 marks
- Attempt the Quanta to Quarks option.
- Allow about 45 minutes for this part.

Section I
75 marks

Part A- 20 marks
Attempt Question 1-20
Allow about 35 minutes for this part

Use the multiple choice answer sheet for Questions 1–20. Choose the most correct alternative.

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1. The Landsat 7 satellite orbits Earth at an altitude of approximately 700 km. The International Space station orbits at an altitude of 330km.

Which of the following correctly compares the orbital velocity and orbital period of these satellites?

	International Space Station	*Landsat 7*
(A)	Greater orbital velocity	Shorter orbital period
(B)	Lesser orbital velocity	Shorter orbital period
(C)	Greater orbital velocity	Longer orbital period
(D)	Lesser orbital velocity	Longer orbital period

2. Which of the following best describes Newton's analysis of escape velocity?

(A) A projectile launched with a great enough velocity would escape Earth's gravity?

(B) A projectile would travel in a straight line until it ran out of momentum, then it would fall.

(C) A projectile launched from the equator towards the east with a great enough velocity would orbit Earth.

(D) A projectile would travel in a parabolic path because it has constant horizontal velocity and constant acceleration.

3. A scientist at a particle accelerator laboratory observes the lifetime of a particular subatomic particle to be 1.0×10^{-6}s when it is travelling at 0.9 c.

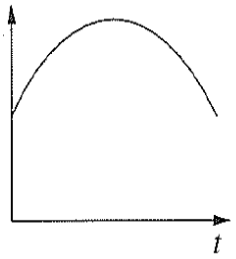
What would the lifetime of the particle be if it were stationary in the laboratory?

(A) 1.4×10^{-8}s
(B) 4.5×10^{-8}s
(C) 0.9×10^{-6}s
(D) 4.4×10^{-7}s

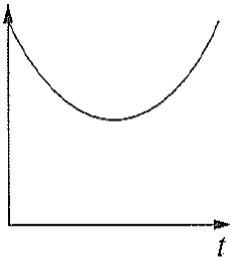
4. A ball was thrown upward at an angle of 45°. It landed at the same height as thrown.

Which graph best represents the vertical velocity component of the ball during its time of flight?

. **(A)**



(B)



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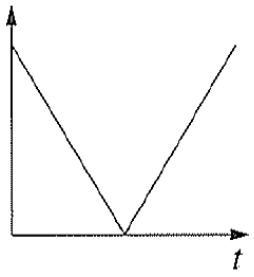

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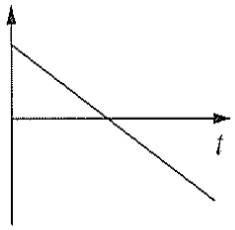
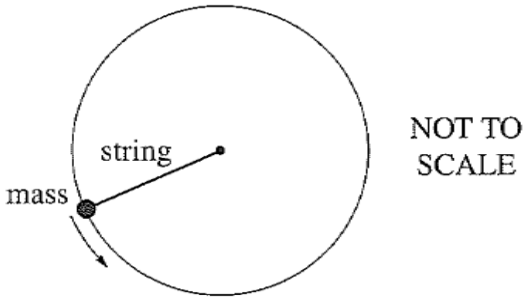


5. A 200 g mass is swung in a horizontal circle as shown. It completes 3 revolutions in 5 seconds. The circle has a 2 m radius.



Which of the following forces is closest to that required to keep the mass moving in this circle?

(A) 0.50 N

(B) 5.5 N

(C) 10 N

(D) 20 N

6. Which statement about Thomson's q/m experiment is correct?

(A) It was a valid experiment because it tested the principle of relativity.
(B) It was a valid experiment because it took into account the known properties of magnetic and electric fields.
(C) It was an invalid experiment because it did not take into account the particle nature of light.
(D) It was an invalid experiment because the speed of cathode rays could not be determined.

7. The acceleration due to gravity on the surface of Mercury is 3.6 m s^{-2}.

What is the mass of a 2.0 kg brick on Earth and on Mercury?

	Mass of brick on Earth	*Mass of brick on Mercury*
(A)	2.0 kg	2.0 kg
(B)	19.6 kg	7.2 kg
(C)	19.6 N	19.6 N
(D)	19.6 N	7.2 N

8. While drilling into tough material, the DC motor in an electric drill is slowed significantly. This causes its coils to overheat.

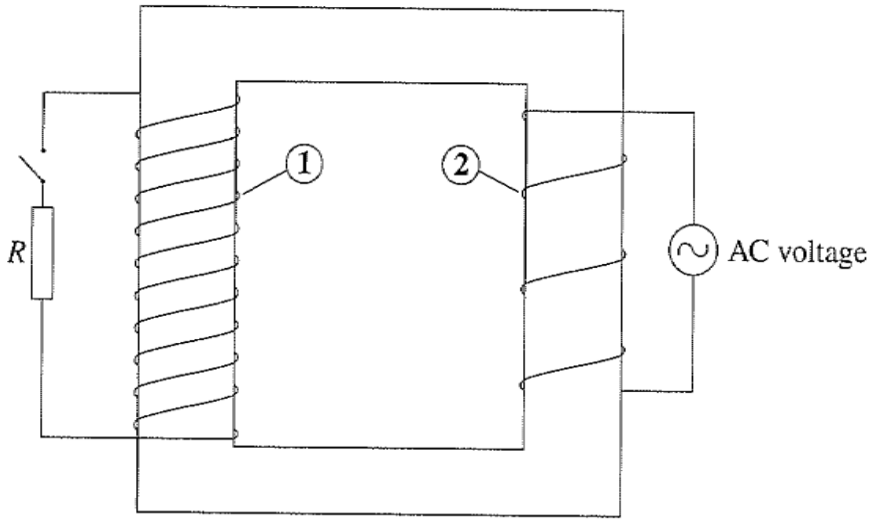
Choose the most correct statement below:

(A) The resistance of the coils increases with loss of speed.
(B) At lower speeds increased friction on the drill is converted to heat and greater current.
(C) The back emf increases and so the current in the coils increases.
(D) Loss of speed increases net forward voltage through coils.

9. The possible application of superconductors in the transmission of electrical energy from power stations to users?

(A) May produce efficiency gains by reduction of line loss.
(B) May only be possible if temperature greater than T_c are maintained.
(C) May maximise the effects of the electrical resistance of the wires.
(D) Will ensure that, even with voltage losses, 240V efficiency will be 100%.

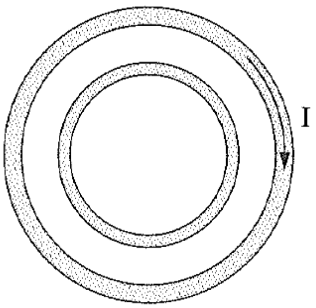
10. The diagram shows a model of a transformer in a circuit.



Which of the following correctly identifies Part 1 and Part 2 and the current in coil 2?

	Part 1	***Part 2***	***Current in coil 2***
(A)	Primary coil	Secondary coil	Less than coil 1
(B)	Secondary coil	Primary coil	Less than coil 1
(C)	Primary coil	Secondary coil	Greater than coil 1
(D)	Secondary coil	Primary coil	Greater than coil 1

11. Two copper rings lie in the same plane as shown.



A decreasing current flows clockwise around the outer ring.

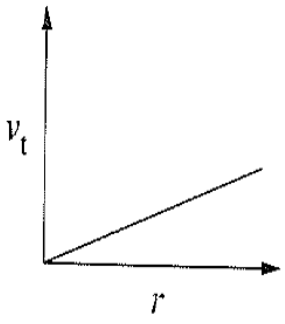
What happens in the inner ring?

(A) An induced clockwise electron flow.
(B) An induced anticlockwise electron flow.
(C) An induced magnetic field grows out of the page.
(D) An induced anticlockwise magnetic field is produced.

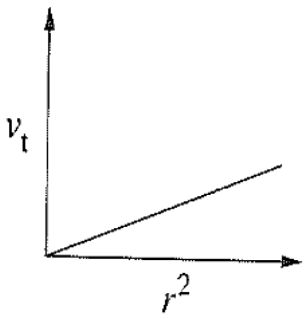
12. The terminal velocity (v_t) of a spherical object in Earth's atmosphere is proportional to the square root of its radius (r).

Which graph correctly shows this relationship?

(A)



(B)



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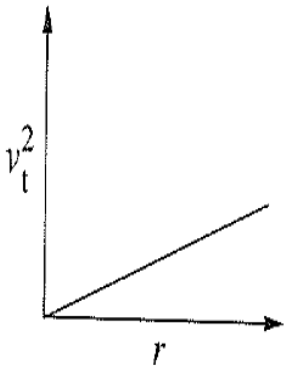

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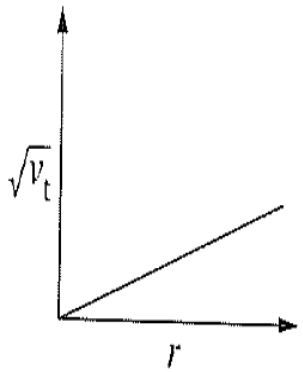


13. What was Albert Einstein's contribution to the development of quantum physics?

(A) He combined the quantised wave and particle models of light.

(B) He analysed the photoelectric effect and described light as quantised energy packets.

(C) He explained black body radiation and the photoelectric effect using quantised energy.

(D) He hypothesised that the radiation emitted and absorbed by the walls of a black body cavity is quantised.

14. Heinrich Hertz devised and performed an experiment to investigate electromagnetic waves. In this experiment he was able to determine the speed of the waves.

Which method was used to determine the speed?

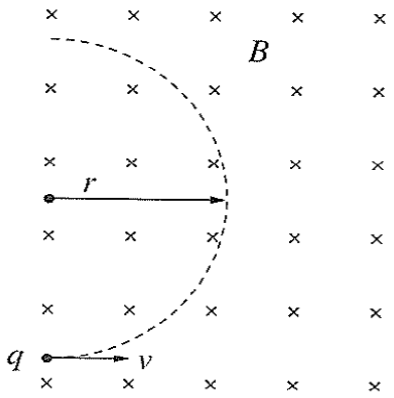
(A) Timing how long it took the wave to travel a known distance.

(B) Producing a wave of known wavelength and using reflection to determine the frequency.

(C) Producing a wave of known frequency and using interference to determine wavelength.

(D) Using an interference pattern to determine the distance travelled and time taken.

15. A charged particle, q, enters a uniform magnetic field B at velocity v. the particle follows a circular path of radius r as shown.



If the magnitude of the magnetic field was tripled and the velocity was doubled, what would the new radius be?

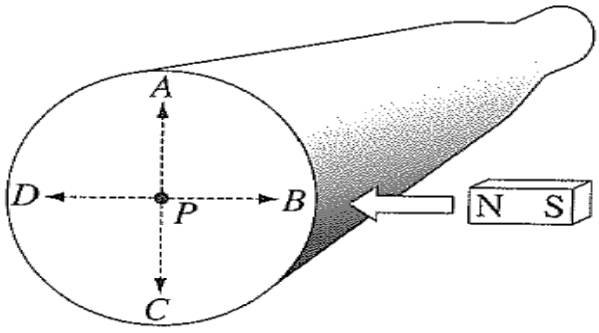
(A) $\frac{3}{2}$ r

(B) 3 r

(C) 6 r

(D) $\frac{2}{3}$ r

16. A positron beam (positive electrons) strikes the screen at point P, producing a bright spot. The north end of a magnet is brought towards the beam a shown.



Towards which point does the bright spot move?

(A) A

(B) B

(C) C

(D) D

17. JJ Thomson determined the charge/mass ratio of the electron by constructing a device which contained

(A) perpendicular magnetic fields, and electric fields and a heated cathode.

(B) perpendicular electric fields, and a heated anode.

(C) parallel electric and magnetic fields, and a heated cathode

(D) perpendicular electric and magnetic fields, and a heated anode

18. William and Lawrence Bragg investigated the layered structure of nickel crystals using

(A) coherent, monochromatic light and an interferometer.

(B) UV light with a wavelength in the order of 10^{-7} m and an interferometer.

(C) EMR with a wavelength in the order of 10^{-7}m and an X-Ray Spectrometer.

(D) EMR with a wavelength in the order of 10^{-10}m and an X-Ray Spectrometer.

19. Why does N type Silicon have a smaller band gap than pure silicon?

(A) Adding gallium contributor positive holes to the lattice which adds on acceptor band.

(B) Adding gallium contributes electrons which form a donor level just below the conduction band.

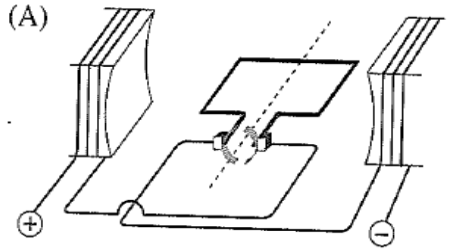
(C) Adding arsenic contributor electrons which provide an acceptor level reducing the band gap..

(D) None of the above are correct.

20. The diagrams show possible ways to connect the coils and rotor of a DC motor to a DC power supply.

In which circuit will the rotor turn in an anticlockwise direction?

(A)



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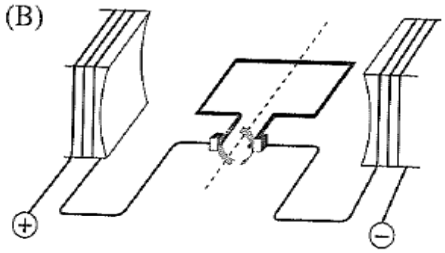

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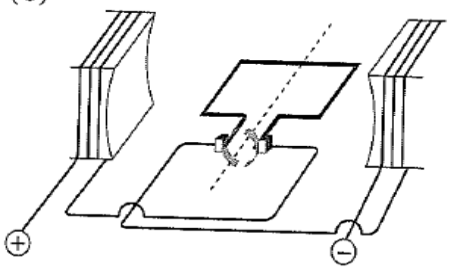

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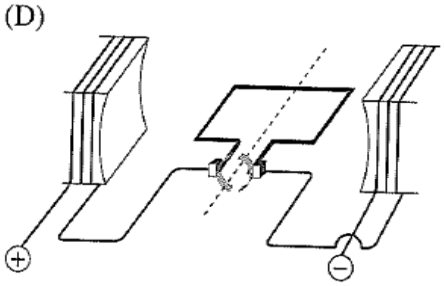


Student Number ……..

Physics

Section 1 (continued)

Part B- 55 marks
Attempt Question 21-32
Allow about 1 hour and 40 minutes for this part

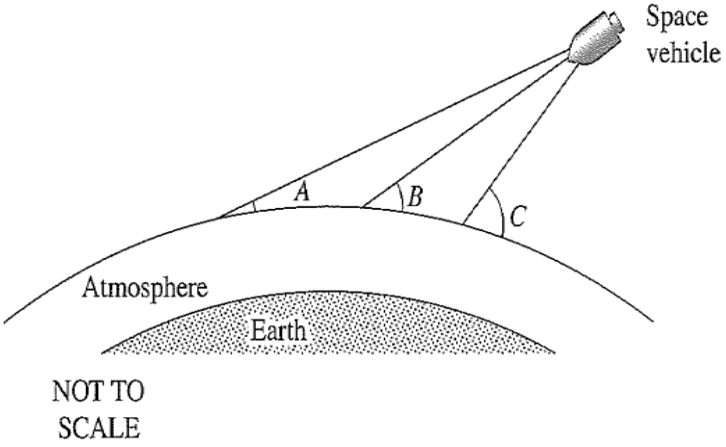
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Show all relevant working in questions involving calculations.

Question 21 (4 marks)

On the return leg of an Apollo space mission the occupants of the Space vehicle proposed 3 possible angles of approach for re-entry to the earth's atmosphere.

A = 6.2° B = 7.2° C = 9.2°

Discuss the 3 suggested approach angles *A, B and C* and give your recommendation of the best approach angle. **4**



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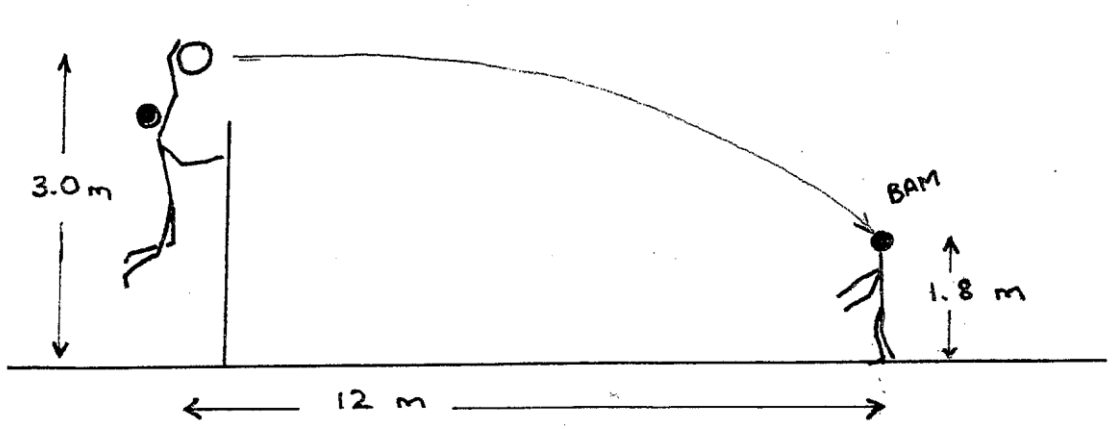
Question 22 (4 marks)

Henry spiked a volleyball at a Grammar boy that hit the boy on the top of the head. The boy was 1.8 metres tall and was standing 12 metres from Henry at the time. Henry hit the ball with a trajectory that was initially parallel to the floor. The contact height of Henry's spike was 3.0 metres of the ground.



(NOT TO SCALE)

(a) Calculate the time of flight of the volleyball **1**

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(b) Calculate the initial velocity of the ball from Henry's spike. **1**

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(c) Calculate the momentum of the volleyball when it hit the Grammar boy (the mass of a volleyball is 226 grams) **2**

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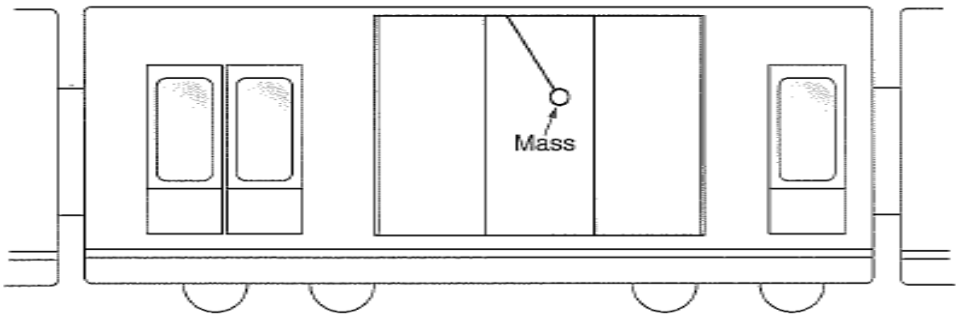
Section I – Part B (continued)

Question 23 (4 marks)

A train is travelling on a straight horizontal track. A student on the train attaches a mass on a string to the ceiling of the train. The student observes that the mass remains stationary in the position shown.



(a) The string then breaks and the mass falls. **2**

Indicate the path of the mass on the diagram above. Explain why the mass has taken this path.

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(b) At the same time another student on the train is conducting an investigation to verify Einstein's time dilation equation. He does this by comparing his clock to one on the platform as they go by.

Evaluate the validity of the student's investigation. **2**

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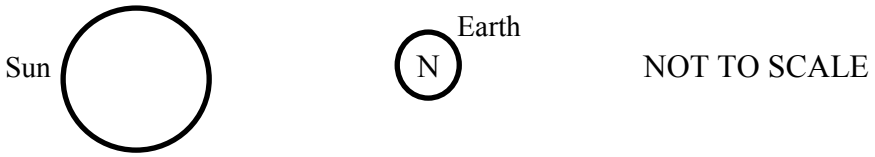
Question 24 (3 marks)

The earth orbits the sun with a period of approximately 365 days. The diagram shows the earth orbiting the sun, viewed from above the earth's north pole.

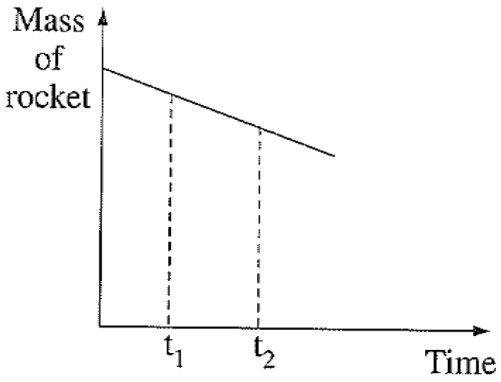


(a) Draw labelled vectors on the diagram to show the net force (F_N) acting on the earth, and the instantaneous velocity (v) of the earth at the position shown. **1**

(b) Calculate the distance between the earth and the sun ($M_{sun} = 2.0 \times 10^{30}$ kg, $T_{earth} = 365$ days) **2**

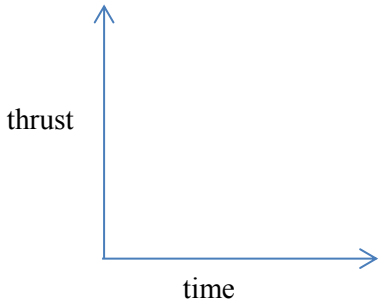
Question 25 (4 marks)

The mass of a rocket decreases during launch as it burns fuel, as shown in the graph. The rocket engine produces a constant upward force on the rocket.

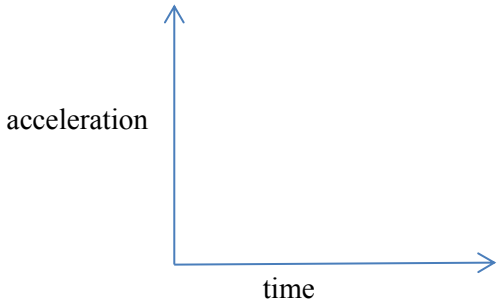


(a) Complete the graphs below to show the qualitative relationship between **2**

(i) Rocket Thrust v time



(ii) Rocket Acceleration v time



(b) Explain the difference between the g forces on an astronaut at times t_1 and t_2. **2**

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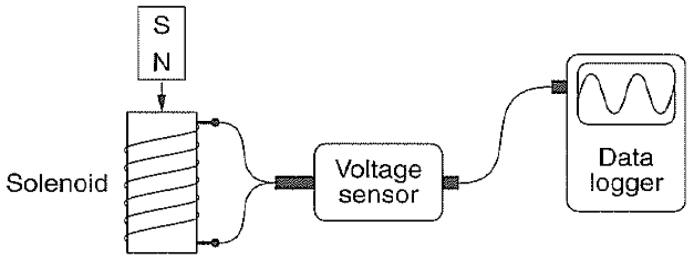
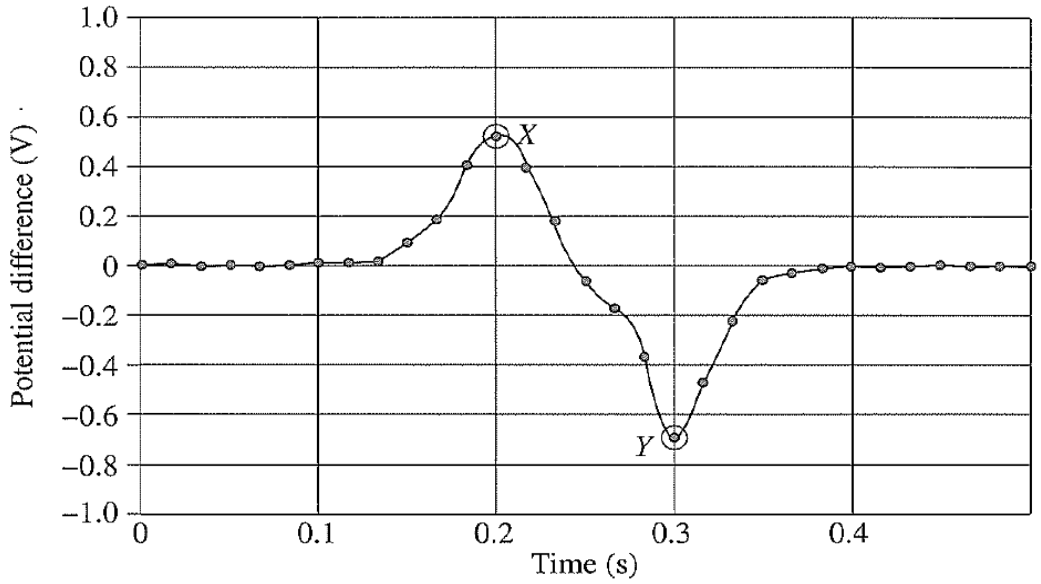
Question 26 (6 marks)

A bar magnet is dropped through the centre of a solenoid connected to a data logger as shown.



The data are recorded in the graph as shown.



(a) Explain the shape of the graph with the reference to Faraday's Law. **3**

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Question 26 continues on the next page.

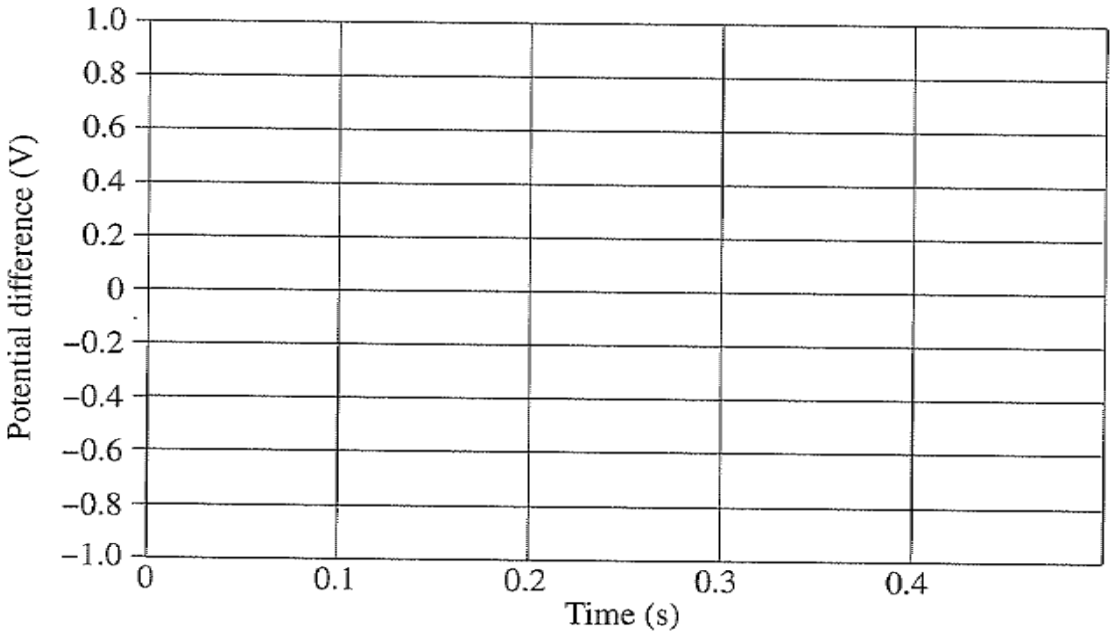
Question 26 (continued)

(b) The magnet is dropped again after the following changes were made. **2**

1. The number of turns on the solenoid was doubled.

2. The south pole of the magnet was pointing down.

Sketch a graph that represents the most likely outcome of this new experiment.



(c) Name a different change that could be made that would increase the rate of change of magnetic flux. **1**

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Question 27 (6 marks) **6**

Thermionic vacuum tube devices have largely been replaced with solid state technology.

Evaluate the impact that solid state devices have had on society and the environment.

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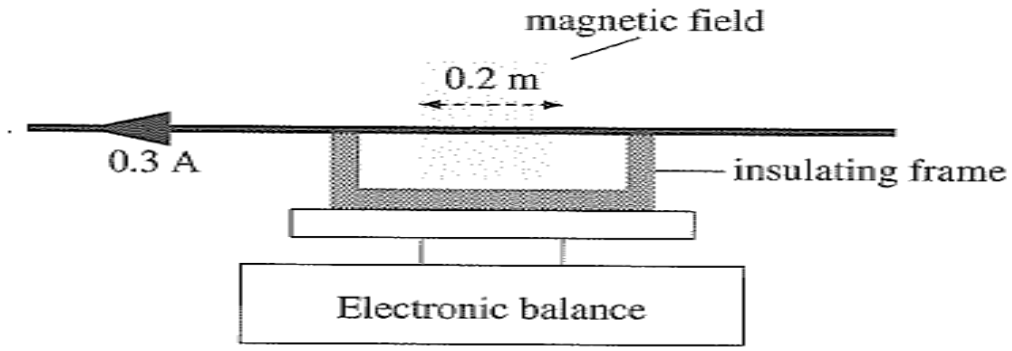
Section I – Part B (continued)

Question 28 (3 marks)

A copper rod is placed on a wooden frame, which is placed on an electronic balance.
A length of 0.2 m of the rod passes at right angles to a horizontal magnetic field.



When a current of 0.3 A is passed through the rod, the reading on the balance decreases from 7.5×10^{-3} kg to 7.5×10^{-4} kg

What is the strength and direction of the magnetic field? **3**

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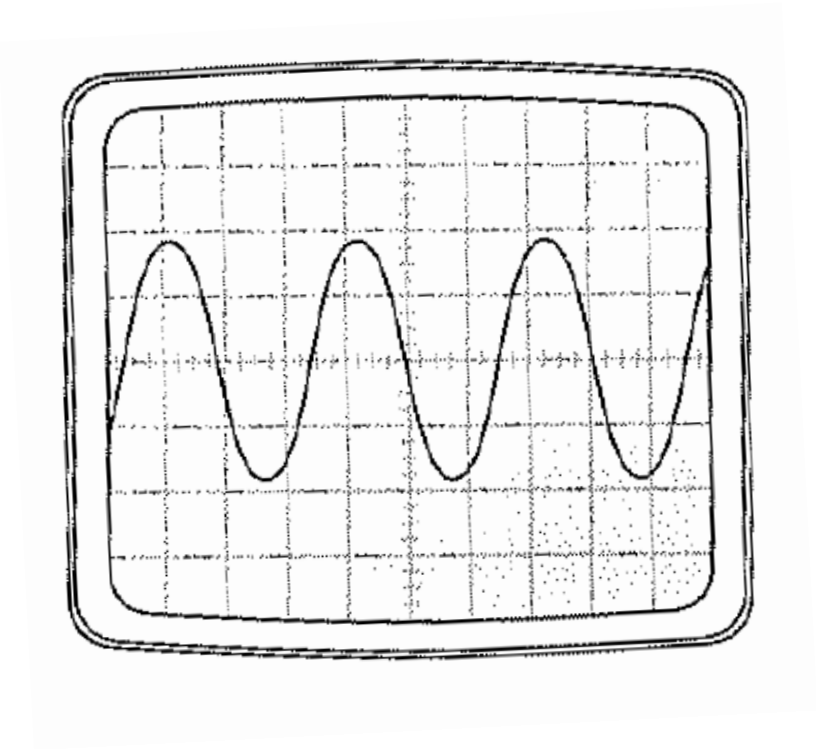
Question 29 (3 marks)

Two sets of plates deflect an electron beam in a cathode ray oscilloscope to produce the trace on the screen shown. **3**



Explain the role of the X deflection plates and the voltage changes that occur across them to control the sweep rate of the cathode ray beam.

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Section I – Part B (continued)

Question 30 (5 marks)

Pure germanium can be doped by adding small amounts of boron or arsenic.

(a) Explain how the addition of arsenic alters the electrical conductivity of germanium. **3**

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(b) Draw a labelled diagram of a p n junction solar cell connected in series to a lamp and a variable resistor. Include current direction (I) in your diagram. **2**

Question 31 (5 marks)

(a) What is the energy of a photon having a wavelength of 4.5×10^5 pm. **2**

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(b) Incident light of frequency well above f_o is directed onto a photoelectric material. With reference to Work Function, explain why emitted electrons have a <u>range</u> of kinetic energies. **1**

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(c) Given that $KE = hf - W$, **2**

Show that $V_s \propto f - f_o$

Where V_s = stopping voltage
f = incident light frequency
f_o = threshold frequency
W = work function

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Question 32 (8 marks)

(a) Tin has been shown to have superconductor properties. Its transition temperature is **-265 ^{o}** C. Draw a graph to show how the electrical resistance of tin changes, above and below the transition temperature. . **2**

(b) Outline the current theory to explain why tin is superconducting at very low temperatures. **2**

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(C) It has been suggested that superconductors could be used to replace the copper cables currently used in large scale electricity transmission. Critically evaluate this proposal. **4**

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OPTION - QUANTA TO QUARKS. **Student number …….**

25 marks. Attempt all questions.

USE THE SEPARATE ANSWER SHEET FOR THESE QUESTIONS.

(a) The atomic model underwent rapid change around the turn of the 20th century. Recount modifications to the model of the atom from Thomson (1898) to Bohr (1913) and assess the impact of the Heisenberg Uncertainty Principle on later models. **6**

(b) Calculate the wavelength of the lowest energy visible photon in the Balmer series for hydrogen. **1**

(c) The Bohr model of the atom had a number of shortcomings. (ie things it couldn't explain). Give 4 shortcomings of the Bohr theory. **3**

(d) The Bohr model of the atom has been said to consist of both quantum and classical ideas. State one part of the model which is classical in nature and one aspect that is quantum in nature. **2**

(e) Define diffraction **1**

(f) Explain the significance of the Davisson and Germer electron diffraction experiment on De Broglie's matter wave proposal and the stability of electron orbits in the Bohr atom. **4**

(g) State the Pauli exclusion principle and give one limitation of the Bohr Model of Hydrogen that the Pauli Exclusion Principle accounts for. **2**

(h) Uranium 238 undergoes alpha decay to produce element X. Element X then undergoes beta decay to produce element Y.
Write the transmutation reactions for the two events described above and name elements X and Y **3**

(i) Calculate the mass defect in amu and energy absorbed or released in eV for the following transmutation. **3**

$Ra^{226}_{88} \rightarrow Rn^{222}_{86} + He^{4}_{2}$

(Masses in amu : $He^{4}_{2} = 4.00260$, $H^{1}_{1} = 1.0078825$, $Rn^{222}_{86} = 222.08690$, $Ra^{226}_{88} = 226.09600$)

End of paper

Used for marking

ANSWERS

SYDNEY BOYS HIGH SCHOOL

Trial Physics Examination

2011

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board- approved calculators may be used
- A data sheet, and formulae sheets Periodic Table are provided at the back of this paper

Total marks - 100

Section 1

75 marks
This section has two parts, Part A and Part B

Part A – 20 marks
- Attempt questions 1 – 20
- Allow about 35 minutes for this part

Part B - 55 marks
- Attempt Questions 21-32
- Allow about 1 hour and 40 minutes for this part

Section II
25 marks
- Attempt the Quanta to Quarks option.
- Allow about 45 minutes for this part.

ANSWER SHEET

SYDNEY BOYS HIGH SCHOOL

Trial Physics Examination

Multiple Choice Answer Sheet

ANSWERS (not checked)

Student Number .....

Question	A	B	C	D
1			X	
2	X			
3				X
4				X
5		X		
6		X		
7	X			
8				X
9	X			
10				X
11		X		
12			X	
13		X		
14			X	
15				X
16			X	
17	X			
18				X
19				X
20	X			

Student Number .....

Physics

Section 1 (continued)

Part B- 55 marks
Attempt Question 21-32
Allow about 1 hour and 40 minutes for this part

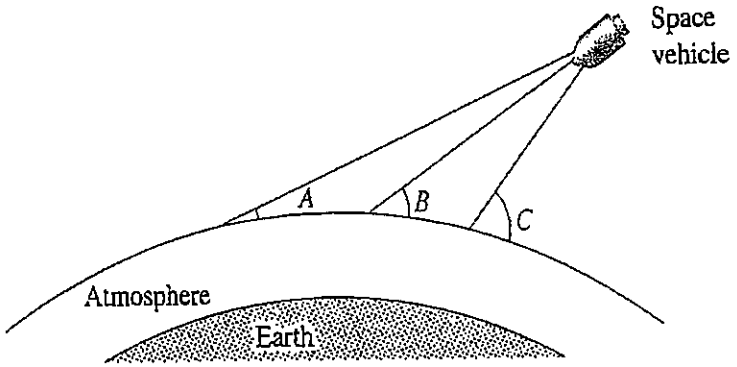
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Show all relevant working in questions involving calculations.

Question 21 (4 marks)

On the return leg of an Apollo space mission the occupants of the Space vehicle proposed 3 possible angles of approach for re-entry to the earth's atmosphere.

A = 6.2° B = 7.2° C = 9.2°

Discuss the 3 suggested approach angles *A, B and C* and give your recommendation of the best approach angle. 4



NOT TO SCALE

ANSWER MUST SPECIFICALLY ADDRESS EACH ANGLE

Marks & ticks in this question

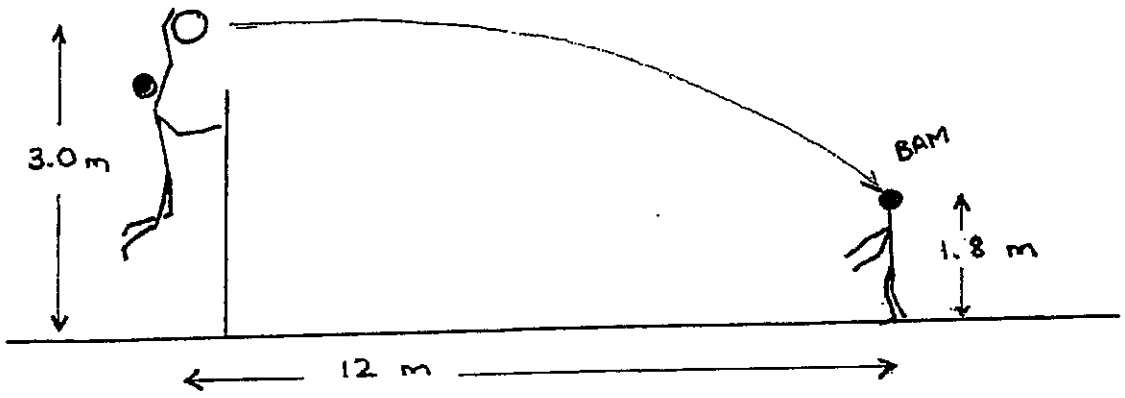
9.2° too steep, vehicle will burn up AND g forces excessive

7.2° on edge of acceptable angles (5.2° - 7.2°) by risky

6.2° - in middle of acceptable range - Recommended

Question 22 (4 marks)

Henry spiked a volleyball at a Grammar boy that hit the boy on the top of the head. The boy was 1.8 metres tall and was standing 12 metres from Henry at the time. Henry hit the ball with a trajectory that was initially parallel to the floor. The contact height of Henry's spike was 3.0 metres of the ground.



(NOT TO SCALE)

(a) Calculate the time of flight of the volleyball 1

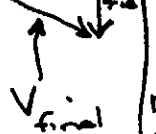
$t = 0.49$ s Correct units and numerical

(b) Calculate the initial velocity of the ball from Henry's spike. 1

$u_x = 24.5$ m/s to the right (not towards player)

* Carry over error ONLY ALLOWED IF EQUATION and SUBSTITUTION LINE ARE CLEARLY WRITTEN

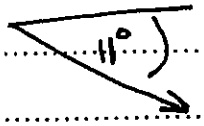
Many did not add $u_x + V_y$ i.e.



V_{final}

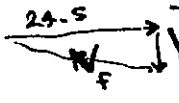
(c) Calculate the momentum of the volleyball when it hit the Grammar boy (the mass of a volleyball is 226 grams) 2

$p = 5.6$ Ns ← 1 mark for numerical OR correct unit



← 1 mark (only payable if numerical correct)

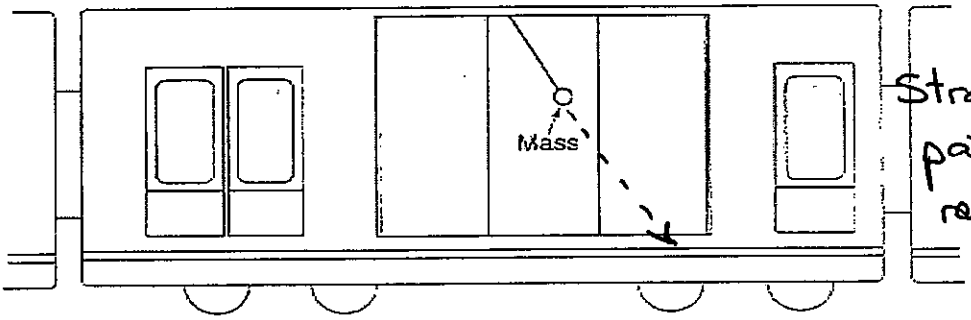
NB: If everything else is correct except direction in (c) a mark can be given for direction if given in (b)



$p = mv = 0.226 \times 24.97 = 5.6$ N ↘ 11°)

Question 23 (4 marks)

A train is travelling on a straight horizontal track. A student on the train attaches a mass on a string to the ceiling of the train. The student observes that the mass remains stationary in the position shown.



Straight line path required

(a) The string then breaks and the mass falls. 2

Indicate the path of the mass on the diagram above. Explain why the mass has taken this path.

Answer should describe accelerated nature of the trains frame of reference AND

- After string cut the mass moves with constant horizontal velocity - the train accelerates away from it.

- the combined vertical and horizontal accelerations produce the path shown.

(b) At the same time another student on the train is conducting an investigation to verify Einstein's time dilation equation. He does this by comparing his clock to one on the platform as they go by.

2 MARKS

Evaluate the validity of the student's investigation. 2

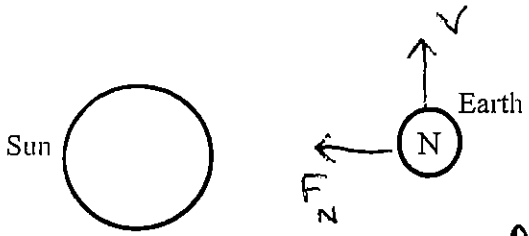
BEST RESPONSE - Expt can't be valid as the train is not an Inertial Frame as required for Special Relativity

ACCEPTABLE - Relativistic speeds are not possible so observable effects will not be measurable

1 MARK - discussion about need for synchronisation

Question 24 (3 marks)

The earth orbits the sun with a period of approximately 365 days. The diagram shows the earth orbiting the sun, viewed from above the earth's north pole.



All correct for 1 mark

(a) Draw labelled vectors on the diagram to show the net force acting on the earth, and the instantaneous velocity of the earth at the position shown. **1**

(b) Calculate the distance between the earth and the sun ($M_{sun} = 2.0 \times 10^{30}$ kg, $T_{earth} = 365$ days) **2**

(Show your working)

1 mark → Correct Equation

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$T = 365 \times 24 \times 60 \times 60$

$= 31536000$ s

$= 9.9452 \times 10^{14}$ s

$$= \frac{6.67 \times 10^{-11} \times 2 \times 10^{30} \times 9.9452 \times 10^{14}}{4\pi^2}$$

$r^3 = 3.360542 \times 10^{33}$

$r = 1.5 \times 10^{11}$ m ←

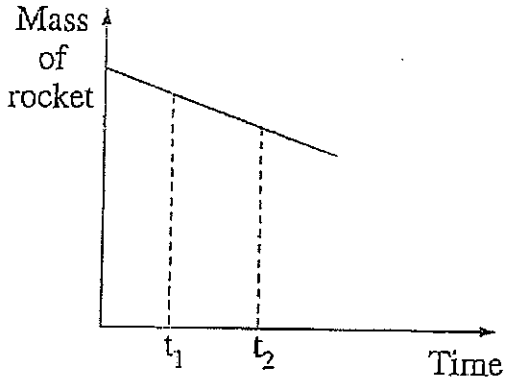
$= 1.5 \times 10^{8}$ km ← or

* Max 3 Sig. Figs

1 Mark (all correct)

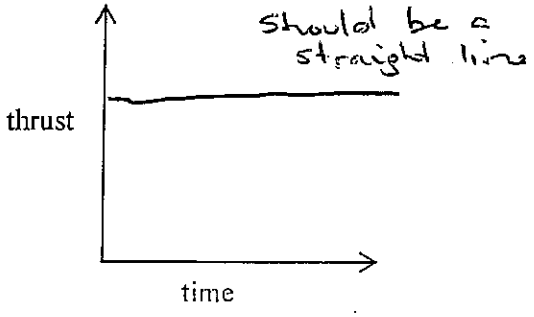
Question 25 (4 marks)

The mass of a rocket decreases during launch as it burns fuel, as shown in the graph. The rocket engine produces a constant upward force on the rocket.

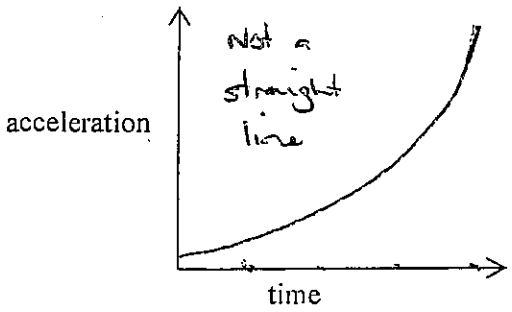


(a) Complete the graphs below to show the qualitative relationship between 2

(i) Rocket Thrust v time



(ii) Rocket Acceleration v time



$F_{th} = ma$

$a = \frac{F_{Th}}{m}$

$a \propto \frac{1}{m}$

(b) Explain the difference between the g forces on an astronaut at times t_1 and t_2. 2

g force greater at t_2 since smaller mass will give greater acceleration and g force = $\frac{a + 9.8}{9.8}$ (for this case)

Answer should identify that ... increase with

1) Mass reduces with time 2) $a \propto \frac{1}{m}$ 3) g's (force related to a)

4) g force greater at 2 than 1. (Must explain using at least 1 algebraic expression that's relevant)

Law of Cons. of Energy.

It applies when energy changes occur. e.g Induction of current or induced K.E (motors).

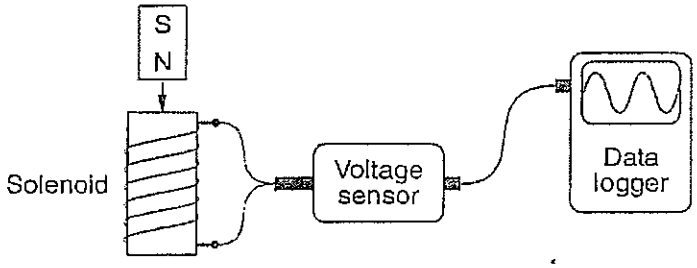
Assume Ideal Voltmeter } Effectively no induced current there as the circuit is OPEN

Energy = VIt, I = 0 ∴ no induced electrical I

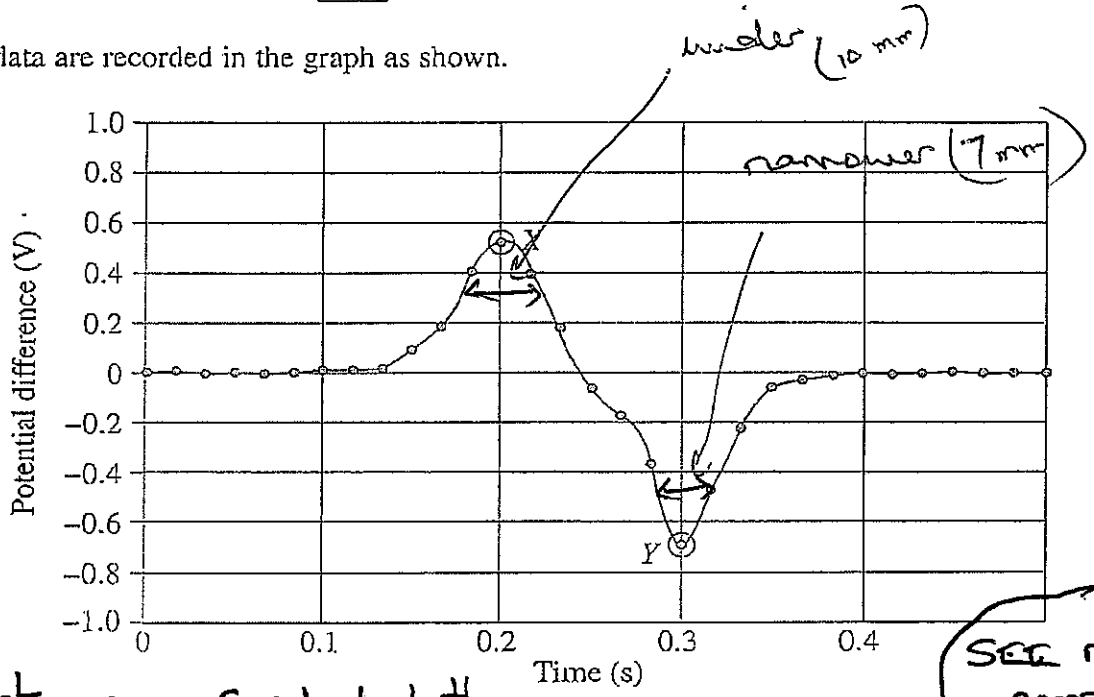
∴ No work done by gravity on the circuit

Question 26 (5 marks)

A bar magnet is dropped through the centre of a solenoid connected to a data logger as shown.



The data are recorded in the graph as shown.



SEE MARKERS COMMENTS

Many students are confused about the application of Faraday's and Lenz Laws (see above)

(a) Explain the shape of the graph with the reference to Faraday's Law. 3

✓ - Faraday's Law - induced emf $= -\frac{\Delta\Phi}{\Delta t}$ or $\Delta V = \frac{-\Delta BA}{\Delta t}$ or stated in words correctly

The max induced voltages at X and Y occur due to change in

✓ OR flux caused by the moving magnet

Induced voltage at Y is negative as the change in flux is opposite to that at X (ie flux is reducing at Y, increasing at X)

✓ - Induced voltage at Y has greater magnitude as magnet is falling faster at Y ∴ $\frac{\Delta BA}{\Delta t}$ is greater.

Question 26 continues on the next page.

Question 26 (continued)

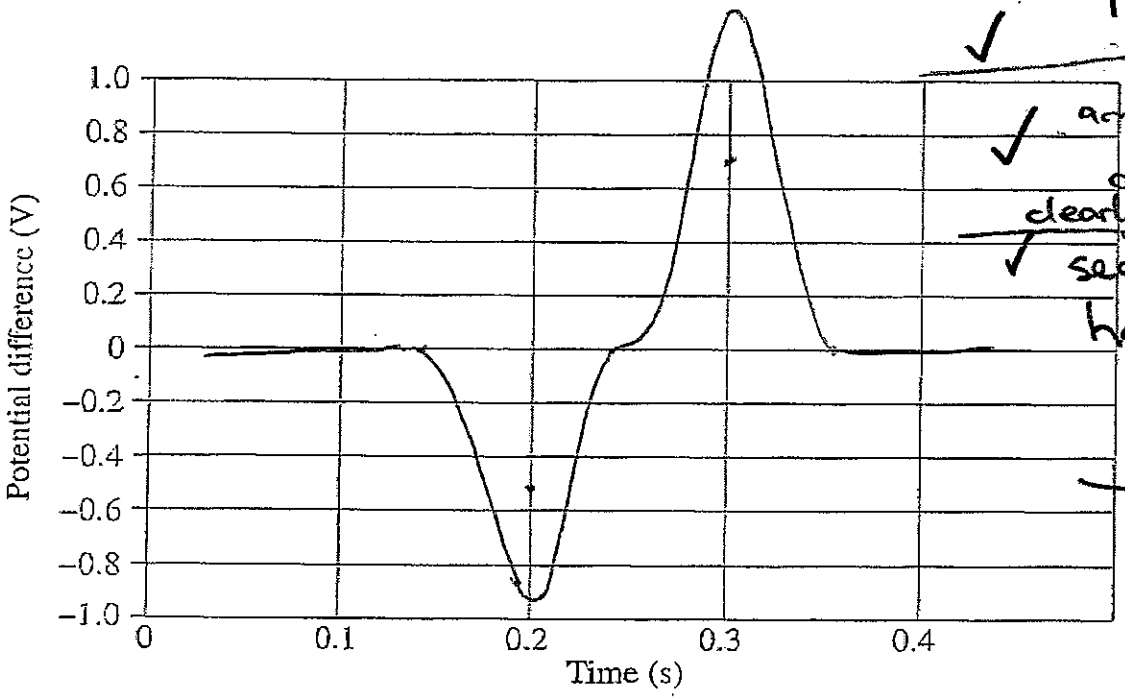
(b) The magnet is dropped again after the following changes were made.

1. The number of turns on the solenoid was doubled.

2. The south pole of the magnet was pointing down.

Sketch a graph that represents the most likely outcome of this new experiment.

2



✓ peaks reversed

✓ amplitude doubled or clearly bigger

✓ second peak has bigger amplitude than first

All 3 ✓ for 2 mark

(c) Name a different change that could be made that would increase the rate of change of magnetic flux. 1

- Stronger magnet OR magnet is thrown faster OR ...

Idea: There may be discernable improvement in handwriting since last year.

Question 27 (6 marks) 6

Thermionic vacuum tube devices have largely been replaced with solid state technology.

Evaluate the impact that solid devices have had on society and the environment.

(Make a judgement based on criteria)

3 MARKS - Discusses criteria, positive and negative, and makes a clear judgement of the impact on society

3 MARKS - Same for environment

- positives
- negatives
- judgement

The 6 points below were used by the marker to monitor the balance of the student response - They don't necessarily = marks awarded

- positives on society
- negatives on society
- positives on environment
- negatives on environment

doesn't equate to final mark given

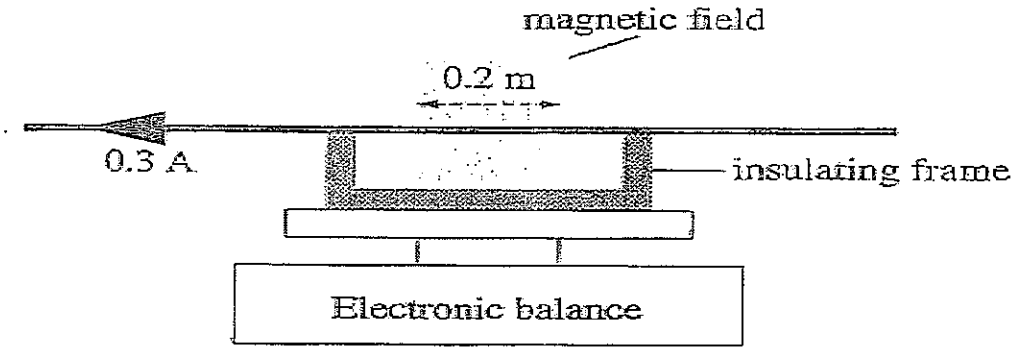
- clear judgement about impact based on criteri
- succinctness, quality of argument, flow of ideas, hand writing is easily readable

Notes: Judgements about impact WITHOUT SUPPORTING CRITERIA are worthless + not considered.

- Many students put too much emphasis on comparing thermionic and S.S. devices, RATHER than focussing their response on IMPACT
- Others LISTED or DESCRIBED impacts but didn't EVALUATE.

Question 28 (4 marks)

A copper rod is placed on a wooden frame, which is placed on an electronic balance.
A length of 0.2 m of the rod passes at right angles to a horizontal magnetic field.



When a current of 0.3 A is passed through the rod, the reading on the balance decreases from 7.5×10^{-3} kg to 7.5×10^{-4} kg

What is the strength and direction of the magnetic field? /3

Field interaction is causing upward force ∴ B is OUT OF PAGE

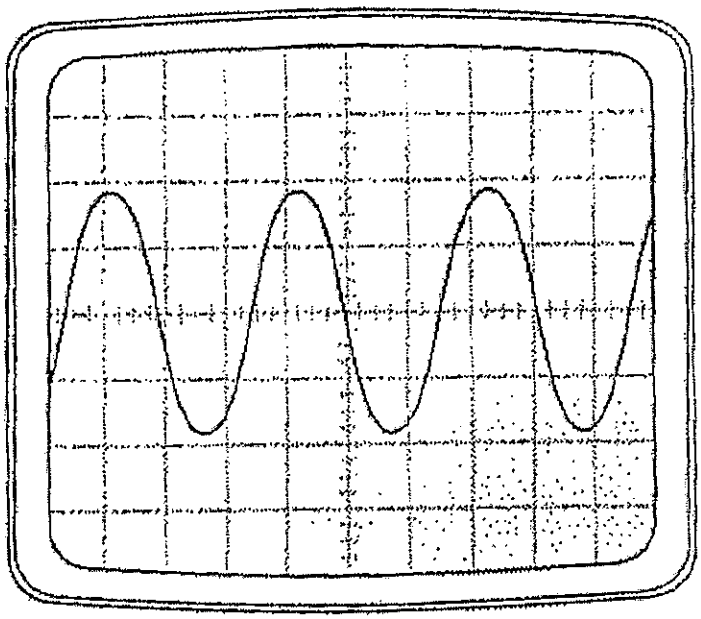
$\Delta F = \Delta mg = (7.5\times10^{-3} - 7.5\times10^{-4}) \times 9.8 = 0.066$ N

$F = BIL\sin\theta$

$B = \frac{F}{IL} = \frac{0.066}{0.3\times0.2} = \frac{0.066}{0.06} = 1.1$ Tesla OUT OF PAGE

Question 29 (3 marks)

Two sets of plates deflect an electron beam in a cathode ray oscilloscope to produce the trace on the screen shown. 3



Note
Explain - cause and effect required.

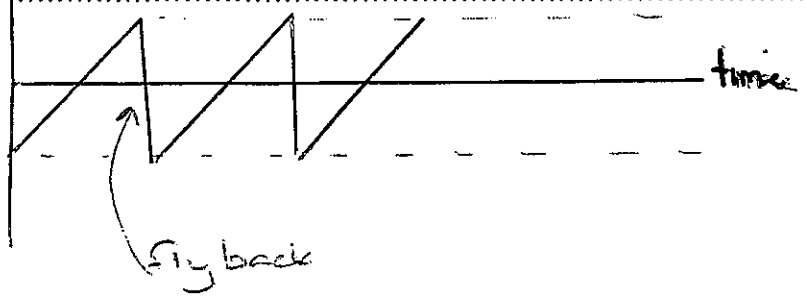
↑ . Many students spoke about both sets of deflection plates - this shows lack of focus on the question at hand.

Explain the role of the X deflection plates and the voltage changes that occur across them to control the sweep rate of the cathode ray beam.

Vertically oriented plates which
- Produces the moving spot across the screen's X axis (horizontal dir'n)
- Is the independent variable - measurement of time (time base)
- The voltage across the 2 plates alternates to move the spot across the screen then quickly reset (varies positive to negative)
- Graph shows voltage variation during 3 sweeps

3 MARKS

Saw Tooth voltage graph on X plates



2 marks
- must clearly explain movement across X axis (of electron beam)
- Caused by regular voltage alternation on X Plates. (not by Magnetic Field variation)

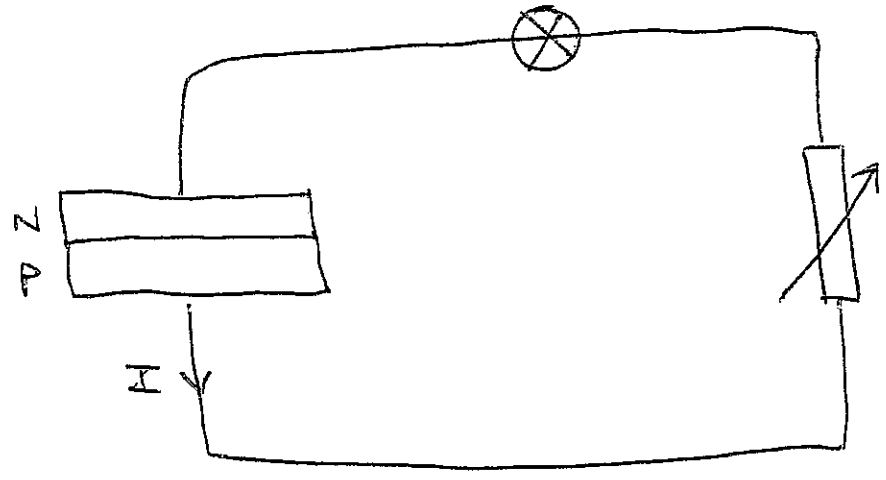
Question 30 (5 marks)

Pure germanium can be doped by adding small amounts of boron or arsenic.

(a) Explain how the addition of arsenic alters the electrical conductivity of germanium. 3

- Arsenic increases the conductivity of germanium
- As adds an extra electron to the lattice (for each As atom). This electron occupies a band just below the conduction band at the donor level
- This results in a lower band gap ie < 0.7 eV
- Produces an N type semiconductor

(b) Draw a labelled diagram of a p n junction solar cell connected in series to a lamp and a variable resistor. Include current direction (I) in your diagram. 2



(No deduction, BUT should be done with ruler and pencil)

This symbol is the correct one, not

subtract on mark for each error

Question 31 (5 marks)

(a) What is the energy of a photon having a wavelength of 4.5×10^5 pm. 2

$\lambda = 4.5 \times 10^5 \times 10^{-12}$ m

$= 4.5 \times 10^{-7}$ m

$E = \frac{hc}{\lambda}$

$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4.5 \times 10^{-7}}$

$= 4.42 \times 10^{-19}$ J

$= 4.4 \times 10^{-19}$ J

2 Marks: . Correct number, units and ≤ 2 sig figs

1 Marks: . Correct formula line with E the subject

NEED
1 ✓ Correct number
1 ✓ ≤ 2 sig fig & units

(b) Incident light of frequency well above f_o is directed onto a photoelectric material. With reference to Work Function, explain why emitted electrons have a range of kinetic energies.

W (Work function) is the minimum E to bring an electron to the surface and $KE = hf - W$. For some electrons, the energy required to be ejected will be greater than W hence the remaining energy to form KE will be reduced. That KE will vary because emission E varies. Alternatively, since question didn't state that $f_{incident}$ was constant, variations in f_i will give a range of KE's (if $f_i > f_o$)

(c) Given that $KE = hf - W$,

Show that $V_s \propto f - f_o$

Where V_s = stopping voltage
f = incident light frequency
f_o = threshold frequency
W = work function

(Work function is the minimum E to bring an electron to the surface, NOT the E to bring any electron to surface)

*It is a CONSTANT For each metal

since $KE = qV_s$

and $W = hf_o$

$qV_s = hf - hf_o$

$V_s = \frac{h}{q}(f - f_o)$

$\therefore V_s \propto f - f_o$

Some students confused
. E_k and E (field strength)
. V_s and $V_{velocity}$

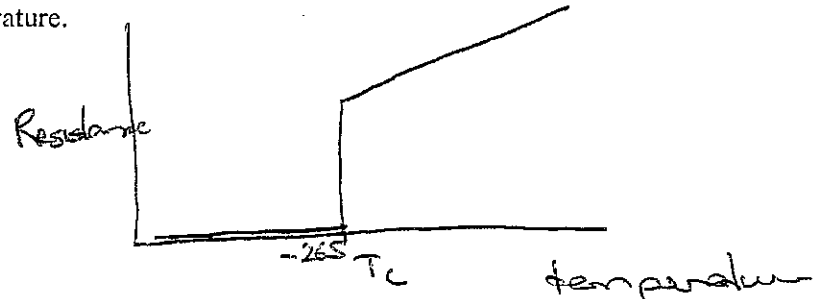
Many incorrectly stated $KE_{max} = V_s$

Physics Student Number .....

Section I – Part B (continued)

Question 32 (8 marks)

(a) Tin has been shown to have superconductor properties. Its transition temperature is **-265** ° C. Draw a graph to show how the electrical resistance of tin changes, above and below the transition temperature. 2



(b) Outline the current theory to explain why tin is superconducting at very low temperatures. 2

(students need to brush up here)

- Brief account of BCS theory

Eg - Lattice cooling & deformation (Lattice) occurs leading to formation of cooper pairs, no of electrons available for conduction band increase and the capacity to move charge increases

(C) It has been suggested that superconductors could be used to replace the copper cables currently used in large scale electricity transmission. Critically evaluate this proposal. 4

(A judgement based on criteria but must demonstrate quantitative accuracy and depth of knowledge)

GUIDELINE FOR MARKS

2 marks
- At least 2 issues / problems (must include temperature issues of type I or Brittleness of type II
- At least 2 benefit - Reference to Type I + II differences

2 marks
- A clear and expanded judgement with criteria, stating whether we should be doing the replacement or not

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For ✳ 4 MARKS - Answer must display . depth of knowledge
. depth of understanding
. strong and clear judgement

OPTION - QUANTA TO QUARKS. **Studeut number .....**

25 marks. Attempt all questions.

USE THE SEPARATE ANSWER SHEET FOR THESE QUESTIONS.

(a The atomic model underwent rapid change around the turn of the 20th century. Recount modifications to the model of the atom from Thomson (1898) to Bohr (1913) and assess the impact of the Heisenberg Uncertainty Principle on later models. **6**

(b) Calculate the wavelength of the lowest energy visible photon in the Balmer series for hydrogen. **1**

(c) The Bohr model of the atom had a number of shortcomings. (ie things it couldn't explain). Give 4 shortcomings of the Bohr theory. **3**

(d) The Bohr model of the atom has been said to consist of both quantum and classical ideas. State one part of the model which is classical in nature and one aspect that is quantum in nature. **2**

(e) Define diffraction **1**

(f) Explain the significance of the Davisson and Germer electron diffraction experiment on De Broglie's matter wave proposal and the stability of electron orbits in the Bohr atom. **4**

(g) State the Pauli exclusion principle and give one limitation of the Bohr Model of Hydrogen that the Pauli Exclusion Principle accounts for. **2**

(h) Uranium 238 undergoes alpha decay to produce element X. Element X then undergoes beta decay to produce element Y.
Write the transmutation reactions for the two events described above and name elements X and Y **3**

(i) Calculate the mass defect in amu and energy absorbed or released in eV for the following transmutation. **3**

$Ra^{226}_{88} \rightarrow Rn^{222}_{86} + He^{4}_{2}$

(Masses in amu : $He^{4}_{2} = 4.00260$, $H^{1}_{1} = 1.0078825$, $Rn^{222}_{86} = 222.08690$, $Ra^{226}_{88} = 226.09600$)

End of paper

Student Number .....

(a) 3 MARKS Recount Thomsons plum pudding to Rutherford orbital / free space to Bohr's Energy level quantum model WITH LABEL DIAGRAMS

3 MARKS Assessment of impact of H.U.Principle -

- H.U.P. had major impact on atomic models after Bohr because it showed that the precise quantitative description of Bohr could not be proven (or disproven) - Hence electron clouds and probability functions (Schrodinger) became part of the later models.

(b) $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ where $n_f = 2$ $n_i = 3$

- OR

Correct answer $\lambda = 6.56 \times 10^{-7}$ m 1 MARK

(c) Subtract 1 mark for each incorrect (or missing) shortcoming (i.e. 2 shortcomings required for 1st mark)

1) Works well for H or atoms with 1 electron only
2) Didn't explain hyperfine splitting
3) Didn't explain zeeman effect
4) Didn't explain why emission lines varied in intensity
5) Mix of classical and quantum ideas

(d) 1 Mark for each correct statement (total 2 MARKS)

CLASSICAL - electrostatic attraction of orbiting electrons

QUANTUM - descrete E levels → photons emitted

(e) Diffraction is the bending of a wave around an obstacle

(f) 4 MARKS Explains that DeBroglie's matter wave proposal addressed electron orbital stability by using standing wave concept but lacked experimental support. Davidson and Germer's experiment provided evidence that particles (specifically electrons) had wave properties

(Marker to develop this for lower marks)

(g) P.E.P. = no 2 electrons can have the same set of quantum numbers — 1 MARK

— Helped account for hyperfine splitting 1 MARK

(h) $_{92}^{238}U \longrightarrow {}_{2}^{4}He + {}_{90}^{234}Th \quad (X = {}_{90}^{234}Th)$

$_{90}^{234}Th \longrightarrow {}_{-1}^{0}e + {}_{91}^{234}Pa + \bar{\nu} \quad (Y = {}_{91}^{234}Pa)$

(Marker to develop rubric to allocate 3 marks)

(i) Mass Reactants = 226.09600 amu = 226.09600 — 1 MARK

Mass Products = 222.08690 + 4.00260 = 226.08950

0.00650 amu — 1 MARK

1 amu = 931.5 MeV/c² $E = 0.00650 \times 931.5 \times 10^6$ eV

$= 6.055$ MeV — 1 MARK